18th SPIG

18th Summer School and International
Symposium on the Physics of Ionized Gases

September 2nd - 6th, 1996, Kotor, Yugoslavia

CONTRIBUTED PAPERS
&
ABSTRACTS OF INVITED LECTURES AND PROGRESS REPORTS

Editors:
B. Vujičić and S. Djurović

Faculty of Sciences, Institute of Physics
Novi Sad, Yugoslavia

USING DIODE LASERS FOR ATOMIC COLLISION PHYSICS

Z.D.Pešić, B.Marinković*, M.Minić, D.Pantelić, I.Nečajev, B.Panić, R.Panajotović
and D.M.Filipović
Institute of Physics, 11001 Belgrade, P.O.Box 57, Yugoslavia

1. INTRODUCTION

Laser diodes have become an important tool in many applications. These lasers have been utilized in laser cooling experiments, have been proposed for use in plasma diagnostics and for optical pumping in atomic time and frequency standards and are also useful in research of atomic collision processes. They are broadly frequency tunable, capable of rapid modulation, easy to use, and inexpensive. Frequency tuning of these lasers is possible due to the inherent sensitivity of their frequency to both temperature and injection current.

Camparo [1] has given an extensive review on the use of diode lasers in atomic physics in 1985. That review covered much of the basic physics and characteristics of diode lasers in simple free-running mode used in low resolution spectroscopy and for optical pumping. Wieman and Hollberg [2] completed the review of using diode lasers for atomic physics covering the relevant characteristics of diode lasers, and explaining various techniques that have been used to control and narrow the spectral outputs.

In this work we present the modified version of current driver for laser diode and we propose the experiments with electron scattering by zinc atom using diode laser.

2. CURRENT DRIVER FOR LASER DIODE

The current stabilization is typically obtained by comparison of reference voltage to the voltage drop produced by the current through a "sense" resistor which is in series with the load. Through careful choice of circuit components and control of the circuit environment, current drift may be reduced to 1 μA/h or better [3].

---

*The author to whom all the correspondence should be addressed; e-mail: marinkovic@atom.phy.bg.ac.yu

The current driver regulates the laser current by comparing a set voltage with a feedback voltage proportional to the laser current. The main sections of the current driver are the control voltage inputs, the feedback loop, and the current display. The desired laser current is selected via the coarse, fine and sweep voltages that are added to produce the set voltage. The difference between the set and feedback voltages controls the base of transistor which is a part of constant current supply circuit. Regulator LM-317 is used to limit the current through laser diode. Current driver can operate in two modes: CC (constant current) and CI (constant intensity). In CI mode the feedback signal is produced by monitor diode whose current is proportional to the output intensity of laser diode.

Laser diode is easily destroyed by voltage spikes and transients. Therefore, we incorporate several features to minimize the likelihood of damaging a laser diode. The transistors is used to slow the turn-on of the laser voltage. Also, a reversed biased diode in parallel to the laser help protect against reverse surges.

The current stability of the designed current driver is under examination.

3. EXPERIMENTAL

Stepwise excitation techniques in which a combination of electron and laser beams are used to excite target atoms are reviewed by MacGillivray and Standage [4]. Measurements of the intensity and the polarization of fluorescence emitted from stepwise excited atoms have provided new techniques for investigating the electron impact excitation of both optically allowed and forbidden atomic transitions. These experiments can be categorized according to whether laser excitation is used in the first or second excitation step. The narrow bandwidth of laser enables the fine structure of atomic transition to be resolved in the laser-excitation step and the role of such structure could be examined in atomic collision process.

For zinc atom as a target, interesting transitions are those of electron excitation of metastable ^3S or ^3P levels and in the second excitation step, laser excitation of higher triplet S or P levels following by detecting fluorescence. This implies case studies of excitation steps: $J=0 \rightarrow J=1 \rightarrow J=2 \rightarrow J=0$ or $J=0 \rightarrow J=2 \rightarrow J=1 \rightarrow J=0$ weak optical excitation and collinear or right-angular geometry as discussed by MacGillivray and Standage [4]. In figure 1, stepwise excitation of zinc triplet states is presented. The 5^3S_1 state is excited by electron impact. The laser excitation step from the 5^3S_1 to the 6^3P_2 level could be reached by diode laser with the frequency of 683.04 nm. By detecting the fluorescence from the 6^3P_1 level to the ground state at 146.884 nm or to the 4^3D level at 1876 nm, integrated cross section for electron excitation of the 5^3S_1 state could be determined.

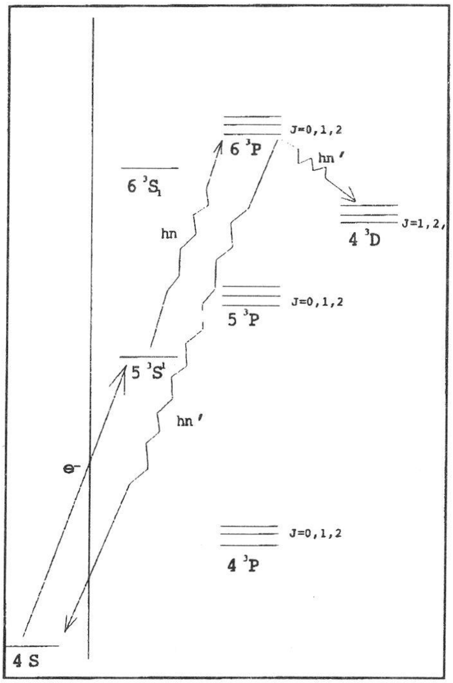

Figure 1 Stepwise excitation of zinc triplet states

Deteremination of partial cross sections for electron excitation of the 5^3P_J states could be done by stepwise excitation of zinc triplet states. In this case, diode laser could be utilized the second step to excite 5^3D_J manifold in the range of wavelengths from 1363.65 nm to the 1378.51 nm. This range of frequences could be reached by cooling standard diode lasers to the temperature of the liquid nitrogen. Fluorescence could be monitored at UV region at 276 nm, transition from the 5^3D to the 4^3P manifold.

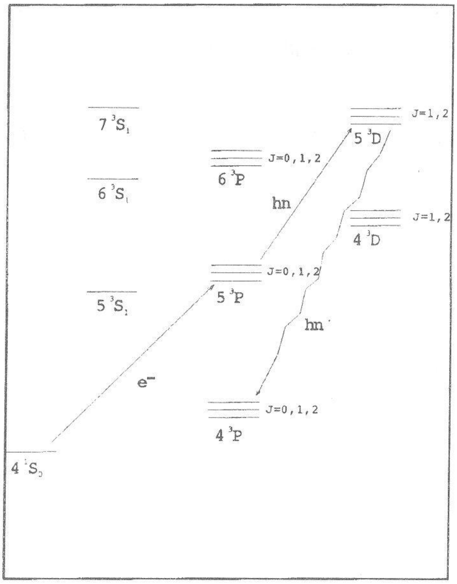

Figure 2 Stepwise excitation of the 5^3P_J manifold

Measurements of partial cross secions of the 4^3P_J states of calcium were performed by this technique except that the monitored fluorescence was at the same frequence as the laser one [5]. To improve the signal/noise ratio authors used modulated electron beam.

ACKNOWLEDGMENTS

This work is a part of the project 01E02 financed by Ministry of Science and Technology of the Republic of Serbia.

REFERENCES

[1] J.C.Camparo, *Contem.Phys.* **26** (1985) 443-77
[2] C.E.Wieman and L.Hollberg, *Rev.Sci.Instrum.* **62** (1991) 1-20
[3] C.C.Bradley, J.Chen and R.G.Hulet, *Rev.Sci.Instrum.* **61** (1990) 2097-101
[4] W.R.MacGillivray and M.C.Standage, *Phys.Rep.* **168** (1988) 1-54
[5] V.E.Dobryshin, V.I.Rakhovskii and V.M.Shustryakov, *Opt.Spectrosc.* **52** (1982) 609-13